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Foods ingested by *Tomocerus* spp. [Collembola, Entomobryidae], in relation to habitat

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Members of the genus *Tomocerus*, as revised by Christiansen (1964), are generally considered to feed on fungi, decaying vegetation, and detritus of the forest floor. Poole (1959) reported that the guts, of *Tomocerus minor* (Lubbock) and *T. longicornis* (Müller) collected in a stand of Douglas fir, contained mostly fungal hyhpae. Knight and Angel (1967), however, studying *T. flavescens* (Tullberg) collected in a hardwood forest, found leaf material to be the dominant constituent of the gut content. Knight and Angel pointed out two possible explanations for the differences between their work and that of Poole. Either habitat differences or species differences might be involved. In our study we attempted to determine whether differences in visible ingested foods are correlated with habitat differences or species differences.

1. Methods

Specimens were collected with an aspirator, and killed and stored in 70% alcohol. The gut contents of adults were then removed and mounted in lactophenol (Gurr 1965) or glycerine. The bolus was divided into 5 equal parts and arranged in order so that the lst sub-sample represented the foremost part of the bolus. The contents of the 5 sub-samples were identified, and each of the seven recognizable categories of food elements given a rank for each sub-sample, on the basis of a scale of 0 to 10,0 meaning that the element was absent, 10 that only the one element was present. The sub-sample ranks were then averaged to produce a rank for each element in the entire bolus.

The seven recorded elements were humus, fungal hyphae, fungal spores, mineral particles, animal parts, pollen grains (pine), and unidentifiable material (possibly corresponding to the „amorphus material" of Knight and Angel). Mineral particles and pine pollen were present in only very low amounts. The animal parts were all *Tomocerus* scales and setae, presumably derived from the shed exuviae, since many Collembola eat the exuviae after ecdysis (Dunger 1964). These 3 elements therefore were not analyzed. The remaining elements were compared statistically for different species of *Tomocerus* found in a single habitat, and for different populations of single species found in diverse habitats. The statistical tests used were the Wilcoxon Two Sample Rank-Sum test for comparisons of 2 populations, and the Kruskall-Wallis test for more than 2 populations (Steele and Torrie 1960).

In the Wilcoxon Two Sample Rank-Sum test a T and T' statistic are calculated for each element in the gut of each pair of populations. If one compares the appropriate T and T' statistic with a critical value (tables 2,4) he can determine whether the element in the gut is more important or less important for the smaller population than for the larger population. In many comparisons tabulated here, the element is neither more nor less important, i. e., there is no statistical difference.

In the Kruskall-Wallis test, an H statistic is calculated for each element in each group of populations compared (tables 3,5). Again the statistic is compared with a calculated critical value, to determine if the element in at least one population of the group is of a different importance than the same element in the other populations of the group. This test does not indicate which of the populations is the source of the difference, but only whether or not difference exists.

2. Results and discussion

Specimens of *Tomocerus* were obtained from 12 different sites (see Table 1 for a summary of sites). Sites 1, 2, and 3 were a beech-maple forest, with some underbrush. Sites 1 and 2 were heavy leaf litter on separate piles of stones about 50 yards apart. Site 3, $^{1}/_{2}$ mile from the preceding two, was in a dry stream bed. It had very little litter layer, but leaf debris and sticks had collected on some of the stones in the bed. Site 4 was located in a predominantly oak forest, with pine and hemlock also present. The *Tomocerus* were taken from a pile of refuse consisting mostly of scraps of pressed board, with some leaf litter cover.

Table 1. Summary of collection sites

Site	Date	Location
1	24. VIII. 1966	Slaterville, N. Y., leaf litter
2	24. VIII. 1966	Slaterville, N. Y., leaf litter
3	24. VIII. 1966	Slaterville, N. Y., dry stream bed
4	30. VII. 1966	Black Moshannon State Park, Pa., refuse pile
5	1. VIII. 1966	Franklin, Pa., refuse pile
6	1. VIII. 1966	Franklin, Pa., under board, dry
7	1. VIII. 1966	Franklin, Pa., under board, dry
8	3. VIII. 1966	Franklin, Pa., under board, wet
9	4. VII. 1966	Ithaca, N. Y., under log, wet
10	15. VII. 1966	Ithaca, N. Y., under log, dry
11	20. VII. 1966	Ithaca, N. Y., under log, wet
12	24. IX. 1966	Ithaca, N. Y., under log, wet

Sites 5, 6, and 7 were located in an old field that had been abandoned for at least 10 years, but which still had only a few small bushes growing in it. Site 5 was the bed of a moist erosion ditch, with no flowing water and no visible organic debris. Sites 6 and 7 were under dry boards. Some organic debris derived from various grasses and annuals was found beneath the boards.

Site 8 was located at the edge of a hardwood forest bordering the aforementioned field on the bank of a small stream. The specimens were taken from under several boards on very moist, sandy soil. Some moss was found on the site, but there was no layer of deciduous leaves or humus since the area was flooded frequently.

Sites 9, 10, 11, and 12 were all under logs. Site 10 was a log at the edge of a woodpile which was partly bordered by a Taxus bush, the rest of the immediate area being lawn. The remaining 3 sites were all logs located at the edge of a small lake, and were quite moist. The predominant vegetation was grasses and annuals, but there was also some deciduous leaf litter from nearby trees.

Two species, *T. flavescens* and *T. elongatus* Maynard were found together in 3 locations, sites 3, 4, and 8. Site 1 yielded the 3 species *T. flavescens*, *T. bidentatus* Folsom, and *T. elongatus*, while specimens of *T. flavescens*, *T. minor*, and *T. vulgaris* (Tullberg) were obtained from site 12. There were no significant differences between the gut contents of the species found at the same site (Tables 2, 3).

Comparisons of populations from several habitats are possible for each of the three species *T. elongatus*, *T. flavescens*, and *T. vulgaris*. Since factors such as humidity, season, etc., could conceivably affect feeding habits, random comparisons of all collections would lead to uninterpretable results. Thus we limited comparisons where feasible, to populations collected within $^{1}/_{2}$ mile (= ca. 804.6 m) of each other, and no more than 3 days apart. This was not possible for *T. vulgaris*, for which 4 populations located within 6 miles (ca. 8.6 km) of each other, and spread over a 3 month period were compared.

Table 2. Statistical values comparing two species of *Tomocerus* from each of 3 habitats

Comparison	Number of specimens in population	Humus		Hyphae		Spores		Undetermined		Critical value*) (Significance level 5%)
		T	T'	T	T'	T	T'	T	T'	
Site 3										
T. flavescens	20									
T. elongatus	7	79.0	117.0	98.5	97.5	131.0	65.0	87.0	107.0	62.0
Site 8										
T. flavescens	37									
T. elongatus	4	112.5	55.5	55.0	113.0	97.5	70.5	48.5	119.5	39.4
Site 4										
T. flavescens	5									
T. elongatus	4	28.0	12.0	25.0	15.0	18.0	22.0	14.0	26.0	11.0

*) T less than the critical value indicates that the element is less important for the smaller population. T' less than the critical value indicates that the element is more important for the smaller population (STEELE and TORRIE 1960, Chapter 21).

Table 3. Values of the H statistic comparing three species of *Tomocerus* from each of 2 habitats

Comparison	Number of specimens in population	Humus	Hyphae	Spores	Undetermined	Critical values of H*) Significance level 5%
Site 1						
T. flavescens	47					
T. bidentatus	6	3.32	0.80	5.81	1.28	5.99
T. elongatus	3					
Site 12						
T. flavescens	16					
T. minor	9	0.88	5.07	4.42	5.49	5.99
T. vulgaris	4					

*) H greater than the critical value indicates that the element, for at least one population, is of different importance than for the other populations (STEELE and TORRIE 1960, Chapter 21).

Table 4. Statistical values comparing one species of *Tomocerus* from two habitats

Comparison	Number of specimens in population	Humus		Hyphae		Spores		Undetermined		Critical values*) Significance level	
		T	T′	T	T′	T	T′	T	T′	5 %	1 %
T. flavescens											
site 1	47	526.5	418.5	485.5	459.5	394.5	550.5	402.0	543.0	353.25	315.84
site 2	15										
T. flavescens											
site 1	47	495.5	864.5	515.0	845.0	861.5	498.5	838.5	521.5	542.56	499.44
site 3	20										
T. flavescens											
site 2	15	353.5	186.5	317.0	223.0	170.0	370.0	216.5	323.5	211.20	192.75
site 3	20										
T. elongatus											
site 1	3	26.0	7.0	20.0	13.0	10.0	23.0	14.0	19.0	7.00	–
site 3	7										

*) T less than the critical value indicates that the element is less important for the smaller population. T′ less than the critical value indicates that the element is more important for the smaller population (Steele and Torrie, Chapter 21).

Table 5. Values of the H statistic comparing one species of *Tomocerus* from three or more habitats

Comparison	Number of specimens examined	Humus	Hyphae	Spores	Undetermined	Critical values *) Significance level	
						5 %	1 %
T. flavescens							
site 5	16						
site 6	13	14.46	8.22	8.97	12.12	7.81	11.30
site 7	7						
site 8	37						
T. vulgaris							
site 9	5						
site 10	10	1.82	2.50	9.10	3.81	7.81	11.30
site 11	10						
site 12	4						

*) H greater than the critical value indicates that the element, for at least 1 population, is of different importance than for the other populations (Steele and Torrie 1960, Chapter 21).

Comparisons were made for the gut contents of *T. flavescens* collected at sites 1, 2, and 3 (Table 4). No differences were detected between specimens from sites 1 and 2, but comparison of specimens from either 1 or 2 with those from site 3 shows similar differences. This is consistent with the descriptions of the sites given previously.

The single possible comparison involving *T. elongatus*, site 1 with site 3, showed no significant differences (Table 4).

Comparisons were made for *T. flavescens* taken at 4 sites located at Franklin, Pa. It can be seen from Table 5 that each of the 4 elements analyzed statistically is distributed differently in at least one of the 4 populations of *T. flavescens*. However, since the sites were different in several ways, such as moisture, organic material, cover, etc., it was not possible to correlate differences in gut contents with any characteristic of the habitat. Therefore, individual pairs of sites are not compared, and no effort was made to find the exact source of the differences.

Comparisons of the gut contents for the 4 populations of *T. vulgaris* resulted in only 1 difference of statistical significance (Table 5). This significance may result from the wide range in time between collections and distance between sites.

The data of this study thus support the second of the 2 alternatives suggested by Knight and Angel (1967), that differences in ingested foods are related to habitat differences. In addition, the data seem to contradict the first alternative, that food differences reflect species differences, but this conclusion could be complicated by several factors. It may be possible that species show preferences for different fungi, a factor which was not detectable by the methods we used. Similarly, those forms found in humus or leaf litter may show preferences for different kinds of leaves. Schaller (1950) has demonstrated that *T. flavescens* shows preference for certain species of decaying leaves. However, his work does not indicate that the preferences of *T. flavescens* would be different from those of *T. bidentatus* or *T. elongatus*, the species commonly found with *T. flavescens* in our work. Another complication could be that various species of *Tomocerus* actually have differences in micro-habitat, so that while they may be feeding upon nearly the same material they are not actually in the same habitats. Factors such as depth in the litter, humidity requirements, or many others could provide micro-habitat differences. This has been suggested by the work of Knight (1963).

No suitable way could be found to measure with accuracy the quantity in each habitat of the various materials identified in the guts, hence little correlation between gut content and the food characteristics of the habitats can be made. Nonetheless, from the comparisons of sites 1, 2, and 3 (Table 4), which seemed to differ mostly in the amount of litter layer, some general conclusions may be drawn. Humus and fungal hyphae are more important constituents of the gut content for populations from a site with a heavy litter layer, while fungal spores and the undetermined portion of the gut content are more important for populations from sites with a sparse litter layer.

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4. Literature

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